

a wind turbine with any number of blades or even on a vertical axis wind turbine. The wind turbine 2 shown in Figure 1 is a relatively small turbine suitable for battery charging or for providing residential power. However, the present invention can be used on any size wind turbine.

5 The blades 4 are mounted on a hub 10 for rotation therewith. The pitch angle of the blades 4 relative to the hub 10 is contemplated as being fixed, although the invention can work equally well with variable pitch blades. The hub 10 is mounted on the nacelle 6 for rotation thereon. The hub 10 may be attached to the nacelle 6 using bearings, bushings, or other suitable attachment. The nacelle 6 is attached to the tower 8 by a yaw bearing that allows the nacelle 6 to rotate about a vertical axis to align the wind turbine with the wind direction. The nacelle 6 is rotated on the tower 8 using a tail vane 12. While the present invention contemplates using a tail vane 12, it would work equally well on a wind turbine that uses an active yaw drive to align the nacelle 6 with the wind direction or on a wind turbine that uses a downwind rotor configuration to orient the nacelle 6 with the wind.

10 Figure 2 shows an exploded view of the wind turbine 2. The wind turbine 2 generates power with an alternator 13. The alternator 13 consists of a stator and a rotor. The stator 14 is shown in Figure 2 as part of the nacelle 6. A rotor is part of the hub 10. The rotor provides a magnetic field and may include permanent magnets or
15 electromagnets. The use of permanent magnets simplifies the design substantially and is preferred, especially for use in small scale wind turbines for battery charging and residential power. The stator 14 includes one or more windings of electrical wire. When the magnetic field from the rotor is rotated relative to the stator 14, then current is

induced in the windings of the stator 14. Most commonly, the stator 14 includes three windings and produces three phase power. However, the present invention can work with any number of windings in the stator 14.

The nacelle 6 also includes a speed sensor 16 for sensing the rotational speed of the hub 10. The speed sensor 16 can be an optical sensor, a hall effect sensor, or any other suitable sensor. The speed sensor 16 provides data input to the controller of the present invention. Instead of providing a physical sensor 16 for measuring the rotor speed, it would be possible to measure the frequency of electrical output from one or more of the phases of the alternator.

The alternator 13 provides an alternating current output voltage and current that must be rectified to direct current for battery charging. A prior art rectifier is shown in Figure 3. The armature 14 can have any number of windings 18, but three windings is the most common configuration as shown in Figure 3. The output of the windings 18 of the armature 14 are input into a rectifier 20. The rectifier 20 consists of six diodes 22 and 24. Three of the diodes 22 provide a positive DC output and three of the diodes 24 provide a negative DC output. The DC output is used to charge batteries 26. In the prior art rectifier, the frequency and voltage of the AC output from the armature 14 vary with the rotational speed of the alternator. While the varying frequency is rectified to DC voltage and current, the DC output voltage is still subject to fluctuations as the rotor speed varies. If the rotational speed of the alternator is too low, then the output voltage will be too low to be useful. This limits the usefulness of the prior art rectifier. Another problem is that the power factor of the output of the prior art rectifier bridge 20 is less

than unity. Furthermore, the output of the rectifier bridge 20 has significant ripple and may not be suitable for some applications that require high quality power.

Figure 4 shows the controller of the present invention in schematic form. The armature 14 of the alternator 13 is shown as having three windings 18, although other numbers of phases could also be used. Each of the windings 18 has an inherent resistance and inductance associated with it. The output of the armature 14 is three phases of alternating current power with the phases labeled as A, B, and C. An RPM sensor 16 measures the rotational speed of the alternator 13 and provides that information to a control module 28. A power electronics module 30 receives the alternating current from the armature 14 and provides single phase direct current output. The power electronics module 30 includes a sensor for measuring various electrical properties, such as current and voltage, and provides that information to the control module 28. The control module 28 in turn provides information to the power electronics module 30 about switching frequency and duty cycle for the components in the power electronics module 30.

Figure 5 shows the circuitry of the controller of the present invention. The circuitry of the controller is similar to the boost converter described in US Patent Number 5,793,625 to Balogh, the specification and drawings of which are incorporated herein by reference. The output of the windings 18 of the armature 14 are fed into a three phase bridge. The bridge has a positive side and a negative side. Each phase includes a diode 32 on the positive side of the bridge. On the negative side of the bridge, each phase includes a diode 34 and a switching device 36 in parallel. The switching devices 36 can be FETs, IGBTs, or similar switching devices. In the preferred embodiment, the switches